EVALUATION OF CHOROID THICKNESS CHANGES AFTER UNEVENTFUL PHACOEMULSIFICATION SURGERY USING SPECTRAL DOMAIN OPTICAL COHERENCE TOMOGRAPHY AT A TERTIARY CARE EYE HOSPITAL

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ABSTRACT

Objective: To analyze the effects of uneventful phacoemulsification surgery on choroidal thickness using spectral domain optical coherence tomography.

Study Design: Prospective comparative study.

Place and Duration of Study: Armed Forces Institute of Ophthalmology, Rawalpindi, from Jun 2018 to Jun 2019.

Methodology: In this prospective study, 300 eyes of 300 patients undergoing phacoemulsification surgery were included. All patients underwent detailed ophthalmologic examination, including measurement with optical biometry, intraocular pressure and choroid thickness. The choroidal thickness was measured perpendicularly at the fovea using spectral domain optical coherence tomography preoperatively and 1 month postoperatively. Changes in intraocular pressure and choroid thickness after surgery were evaluated.

Results: There was a statistically significant increase in the choroid thickness in early postoperative period (p-value <0.01). This increment was prominent in sub foveal regions. The intraocular pressure decreased significantly 1 month after surgery (p-value <0.01). The change in intraocular pressure was correlated with the choroid thickness change at sub foveal region.

Conclusion: Uncomplicated phacoemulsification induces non-pathologic increase in sub-foveal choroid thickness probably due to the inflammatory insult of the surgery. Long-term follow-up of eyes having phacoemulsification surgery may provide further insight into the effects of cataract surgery on the choroid.

Keywords: Optical coherence tomography, Phacoemulsification, Sub-foveal choroidal thickness.

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INTRODUCTION

Choroid is highly vascular structure lying between retinal pigment epithelium and lamina fusca of sclera, supplying blood to outer retinal layers. It plays an important role in various vision deteriorating diseases such as age related macular degeneration, choroidal neo-vascularization, central serous chorioretinopathy and chorioretinal atrophy in high myopia.[1,2] Choroidal thickness is determined by amount of vascularization and varies by age, sex, refractive state of eye along with any previous history of ocular trauma or surgery like cataract extraction.[3-5] Phacoemulsification is most common invasive intraocular surgery for removal of cataract and improves visual outcome markedly. In this procedure, opaque crystalline ocular lens is emulsified with an ultrasonic hand piece, aspirated from eye, and replaced by intra ocular lens implant.[6] It is otherwise a safe procedure but it is associated with complications if coexistent with diabetic retinopathy, chorioretinal atrophy and can cause pseudophakic cystoid macular edema (Irvine-Gass-syndrome).[7] These complications are speculated to be induced due to inflammatory reactions, increased free radicals formation leading to release of growth factors and prostaglandins leading an increase in choroid thickness observed after phacoemulsification.[8,9]

Previously, measurement of choroid thickness was restricted to ultrasonography. Currently, optical coherence tomography has steadily evolved into an integral element in diagnosis and progression of retinal and choroidal disease. It provides cross sectional images of chorioretinal morphology and quantification of disease effects in the form of thickness maps. A recent advance in optical coherence tomography technology, spectral domain optical coherence tomography (SD-OCT) has significantly increased scanning speeds (more than 100 folds).[10] Fast acquisition speed and higher resolution images of SD-OCT provide useful information of choroidal thickness. It obtains sub-surface images of translucent materials based on low coherence interferometry, characteristically employing near infrared light. This longer wavelength light penetrates into scattering medium of choroid and achieves its

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sub-micrometer resolution. Post-operative choroidal thickness measurement will aid in understanding pathogenesis of retinal and choroidal changes leading to pseudophakic cystoid macular edema. This edema compromise the vision and affects patient satisfaction of not re gaining visual acuity even after surgery.

METHODOLOGY

This prospective comparative study was started after taking approval by ethical committee of Armed Forces Institute of Ophthalmology (AFIO), Rawalpindi (reference number 231/ERC/AFIO), from June 2018 to June 2019.

Inclusion Criteria: The patients visiting cataract clinic with visually significant lenticular opacity were included.

Exclusion Criteria: Patients with co-existent systemic diseases, or having other ocular diseases including uveitis, glaucoma, retinal detachment, retinal vascular occlusive disease, retinal inflammatory diseases, secondary complicated cataract and eyes with previous ocular surgeries or patients unable to sit upright were excluded from the study.

Patients were briefly described about the procedure. Informed consent was taken from all patients who agreed to participate in the study. A total of 300 patients were included in the study using non-probability consecutive sampling technique. The sample size was calculated by using WHO sample size calculator keeping 95% confidence interval and 5% error.[11] All enrolled patients had age related cataract as only ocular disease. Patients underwent uncomplicated phacoemulsification by same surgeon.

Lens Opacities Classification System (LOCS III) staging was used to standardize cataract hardness of patients.[12] Severe dense brown cataract that might have caused unreliable SD-OCT measurement because of reduced penetration and poor fixation were not included in study.

Phacoemulsification (Centurion vision system, Alcon Laboratories, USA) was performed. About 2.8 mm superotemporal triplanar clear corneal incision was made in all surgeries. Hydrophobic Acrylic Intra Ocular Lens (AcrySoft IQ, Alcon laboratories, USA) was implanted in all enrolled patients. Patients were advised topical Moxifloxacin, topical prednisolone and topical Nepafenac eye drops for six weeks post operatively.

Pre-operatively all enrolled patients underwent detailed ophthalmic examination along with fundoscopy after pupillary dilation. It included visual acuity measurement, best corrected visual acuity, anterior segment bio-microscopy, intraocular pressure measurement. Axial length and intra ocular lens power was measured by optical biometry (IOL Master 700, Zeiss, Jena, Germany) in all cases. Choroid thickness measurement using SD-OCT were taken between 9:00 am and 12:00 am to avoid effects of diurnal fluctuations. Intraocular pressure was measured using Goldman Applanation Tonometer pre-operatively and 4 weeks post operatively. Intraocular pressure measurement was performed after SD-OCT imaging as applanation by GAT may cause inadvertent transient corneal edema.

Enhanced Depth Imaging–Optical Coherence Tomography (EDI-OCT) with Spectralis OCT (Heidelberg Engineering, USA) was used to image choroid and measure its thickness. EDI-OCT B-Scans average 100 times, centered on fovea were obtained for each patient pre-operatively and these scans were marked as patient's baseline scans. These baseline scans were used as reference for subsequent scans using option of "following up" in Spectralis Heidelberg software with the patient in same position. These scans were repeated four weeks post operatively after phacoemulsification.

Measurement of choroidal thickness was performed manually using "measuring calipers" centered on fovea provided by Spectralis Heidelberg software. Thickness of choroid was measured by sections passing through fovea vertically. Choroidal margins were considered as the distance between outer edge of hyper reflective retinal pigment epithelium and internal margin of choroidal scleral junction (Figure). Images with good signal strength were taken.

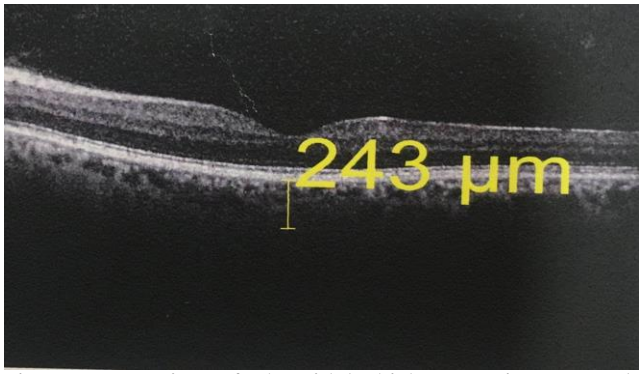

Figure: Measuring of choroidal thickness using manual calipers.

The surgical procedure was similar for all enrolled patients. Cataract surgery was performed by

phacoemulsification. Intraocular lens were implanted in capsular bag. There were no complications during surgeries. Time elapsed between corneal incisions till stromal hydration was considered as surgical time. Post operatively, all patients were advised Moxifloxacin eye drops four hourly initially for two weeks followed by six hourly for another six weeks. Topical non-steroidal anti-inflammatory eye drops were prescribed twice daily for four weeks and topical prednisolone was advised four hourly for initial two weeks and then six hourly for another four weeks.

Data was analyzed by using Statistical Package for the social sciences (SPSS) version 23. Descriptive statistics were used to calculate mean with standard deviation for quantitative data and frequency and percentages for qualitative data. Paired-samples *t*-test was used for comparison between means of preoperative and postoperative of sub foveal choroidal thickness measurements. Evaluation was made at a 95% confidence interval, and the *p*-value of ≤0.05 was considered statistically significant.

RESULTS

In this study a total of 300 patients were enrolled. The mean age of the patients was 65.06 ± 5.70 years. Majority 180 (60%) of the patients had age more than 65 years and 120 (40%) patients were younger than 65 years. Main bulk 222 (74%) of the patients in our study sample were males and 78 (26%) were females. Cataract severity was classified as per Lens Opacification Classification system (LOCS). LOCS I being mild and LOCS IV being dense cataract and affecting vision markedly. Out of 300 patients, 96 (32%) and 198 (66%) had cataract severity falling into LOCS II and LOCS III respectively. Only 6 (2%) patients had cataract severity of LOCS IV. Mean surgical time was 15.62 ± 1.28 minutes. Descriptive statistics of patient characteristics given at Table-I. The statistically significant (*p*-value <0.01) increase in choroid thickness was noted after surgery in sub-foveal regions. However, intraocular pressure significantly decreased (*p*-value <0.01) in early post-operative period than preoperatively. Detailed comparison of sub foveal choroid thickness and intraocular pressure is given at Table-II.

Table-I: Descriptive statistics of patient characteristics.

Characteristics	n (%)
Age of Patients (Mean ± SD) 65.06 ± 5.70 Years	
≤65 years	120 (40)
>65 years	180 (60)
Gender of Patients	
Male	222 (74)
Female	78 (26)
Cataract Severity on Basis of Lens Opacification Classification System (LOCS)	
LOCS – I	-
LOCS – II	96 (32)
LOCS – III	198 (66)
LOCS – IV	6 (2)
Mean Surgical Time (Mean ± SD) 15.62 ± 1.28 minutes	

Table-II: Comparison of sub foveal choroid thickness and intraocular pressure in the study groups.

Parameters	Categories	Mean ± SD	*p*-value
Overall Comparison			
Sub Foveal Choroid Thickness (µm)	Pre-Operatively	233.46 ± 9.52	<0.01
	Four Weeks Post-Operatively	276.80 ± 16.75	
Intraocular Pressure (mm of Hg)	Pre-Operatively	18.64 ± 3.17	<0.01
	Four Weeks Post-Operatively	16.56 ± 2.97	
Gender of the Patients			
Sub Foveal Choroid Thickness (Pre - Operative)	Male	233.40 ± 9.82	<0.01
	Female	233.61 ± 8.65	
Sub Foveal Choroid Thickness (4 Weeks Post-Operative)	Male	276.16 ± 17.12	<0.01
	Female	278.61 ± 15.62	
Intraocular Pressure (Pre-Operative)	Male	18.67 ± 3.13	<0.01
	Female	18.53 ± 3.31	
Intraocular Pressure (4 Weeks Post-Operative)	Male	16.54 ± 2.92	<0.01
	Female	16.61 ± 3.14	
Age Groups of Patients			
Sub Foveal Choroid Thickness (Pre - Operative)	≤65	228.25 ± 8.74	<0.01
	>65	236.93 ± 8.37	
Sub Foveal Choroid Thickness (4 Weeks Post-Operative)	≤65	267.35 ± 17.29	<0.01
	>65	283.10 ± 13.05	
Intraocular Pressure (Pre-Operative)	≤65	18.15 ± 2.94	<0.01
	>65	18.96 ± 3.29	
Intraocular Pressure (4 Weeks Post-Operative)	≤65	16.30 ± 2.92	<0.01
	>65	16.73 ± 3.00	

DISCUSSION

After phacoemulsification, there was no change in fundoscopic appearance clinically but sub-clinical changes, as indicated by SD-OCT sectioning have been reported in most of eyes undergoing cataract surgery.[13] Cataract surgery, although anterior segment procedure is capable of affecting posterior segment especially in Diabetic retinopathy and Irvine–Gass Syndrome (pseudophakic cystoid macular edema).[14] Dense scanning afforded by SD-OCT allows identification of such retinochoroidal vascular and morphological patterns.

The results of our study are comparable to most of international studies. Ibrahim et al concluded that mean SFCT after cataract surgery increased to up to three months duration.[15] However, in our study choroid thickness was evaluated in early postoperative

period. A meta-analysis conducted by Zeng *et al,* on changes in SFCT after cataract surgery concluded SFCT increased after cataract surgery and this increase lasted for at least 3 months. Asians and patients without NSAIDs in postoperative period were more likely to have a thicker SFCT after cataract surgery thus implying role of post-operative inflammation.[16] Another study conducted by Morrin *et al,* inferred that SFCT increased after cataract surgery and presence of a diabetic retinopathy is critical for evaluation of choroidal thickness as increase in thickness was more marked in eyes of diabetic patients.[17]

Anti-inflammatory therapy is part of our standard post-operative protocol, advised to all our patients for six weeks after surgery. So in this study the actual postoperative choroidal response was evaluated. These anti-inflammatory therapies are known to reduce post-operative inflammations of choroid and retina.

It is suggested that increased in choroidal thickness after surgery is the effect of pro inflammatory cytokines and prostaglandins that are believed to be raised. Surgical trauma to eye impairs blood aqueous barrier leading to accumulation of inflammatory mediators i.e. immune complexes, cytokine and prostaglandins. These inflammatory mediators pass from anterior chamber, vitreous to retina and choroid leading to impairment of inner and outer blood retinal barrier causing an inflammatory cascade.[18,19]

Another mechanism suggested for post-surgical inflammation is increased gene expression that simultaneously induces inflammatory response in all ocular layers. In a mouse model cataract surgery increased protein secretion in the retina and choroid due to expression of pro inflammatory gene related to chemokines such as CCL-2 and SDF-1, both of which can impair the blood–retinal barrier.[20]

Another animal study concluded marked upregulation of IL-1 B, an inflammatory mediator in neurosensory retina, RPE and choroid. A similar response in human eye might explain mechanism of cataract surgery associated inflammation of retina and choroid as evident by raised thickness in our study.[21]

It has been observed that even uncomplicated cataract surgery causes temporary thickening of the retina especially macular area. Factors attributed include high ultrasound power used during procedure, use of ophthalmic visco surgical devices and intraoperative photostress due to microscope light.[22]

In our data cataract, hardness of patients ranged from Grade II to Grade IV based on LOCS III. Dense cataracts were excluded as they prevent reliable OCT Imaging. Only two patients had grade IV cataract. In other words, we had homogenous data as regard to cataract hardness. This limitation has prevented us to detect increase in choroid thickness which may result from higher ultrasonic phaco power and longer surgical time generally required for dense brunescent cataract, putting the patient at higher risk of complications.

In our study, intraocular pressure decreased after cataract surgery. It is comparable to results of study conducted by Ohsugi *et al* who also concluded choroid thickness changes negatively correlated with intraocular pressure early after surgery. Another study conducted by Bayhan *et al* also had similar results[6].

Many factors have been taken into account to understand the mechanism of decrease in intraocular pressure. Extraction of thick ocular lens with cataract widens anterior chamber angle, thus removing blockage and improving aqueous outflow, consequently decreasing intraocular pressure. Although our study shared correlation between changes in choroidal thickness and intraocular pressure in early post-operative, we believe that this will be worth confirming in study with longer post-operative duration. Ocular perfusion pressure is main driving force for ocular blood flow. Reduced intraocular pressure causes increased ocular perfusion that increase choroidal thickness as choroid is rich vascular tissue. Increased SFCT as measured by SD-OCT in our study is indicative of increased choroidal perfusion caused by reduced intraocular pressure in early post-operative period after cataract surgery.

CONCLUSION

Choroidal thickness is significantly increased after cataract surgery. It is correlated with decreased intraocular pressure in early post-operative period. In regular practice, post-surgical inflammatory insult is managed with topical NSAIDs. However, even with this standard practice surgery still induced changes in choroidal thickness. This is especially significant for understanding pathogenesis of retinal and choroidal changes after phacoemulsification such as pseudophakic cystoid macular edema.

Conflict of Interest: None.

Authors' Contribution

AR: Direct, OZ: Direct contribution to conception/ supervision, SK: Intellectual/analysis, HJ: Data collection.

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